

PATENT  
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## CLAIMS

1. A hierarchical memory structure for use in matching a data string having a plurality of fields, the associative memory structure comprising:

- a top-level associative memory; and
- at least one next-level associative memory operably coupled to the top-level associative memory so as to receive an output therefrom, wherein
  - the top-level associative memory is configured to receive and match one or more of the fields of the data string and, in response to detecting a match, providing an output to the next-level associative memory, and
  - the at least one next-level associative memory is configured to receive and match the output from the top-level associative memory plus one or more other fields of the data string or one or more values derived therefrom and, in response to detecting a match, outputting a result.

2. The hierarchical memory structure of claim 1 wherein the data strings being matched are network messages.

3. The hierarchical memory structure of claim 2 wherein the one or more fields input to the top-level associative memory include an Internet Protocol (IP) address field.

4. The hierarchical memory structure of claim 1 wherein the top-level associative memory and next-level associative memory are each ternary content addressable memories (TCAMs) that support don't care values.

5. The hierarchical memory structure of claim 4 wherein the data strings being matched are network messages.

8/. The hierarchical memory structure of claim 1 wherein the output of the top-level associative memory that is received by the at least one next-level associative memory has a length that is shorter than a length of the one or more fields of the data string that are input into the top-level associative memory.

1 ~~10/~~9. The hierarchical memory structure of claim ~~8~~<sup>9</sup> further comprising a first mem-  
2 ory structure associated with the top-level associative memory, the top-level associative  
3 memory and first memory structure configured such that, in response to detecting a match  
4 to an entry in the top-level associative memory, the top-level associative memory speci-  
5 fies a location of the first memory structure containing the output that is provided to the  
6 at least one next level associative memory.

1 ~~11~~ 10. The hierarchical memory structure of claim ~~9~~ <sup>10</sup> further comprising a message  
2 buffer for temporarily storing the data string, and buffer control logic for providing se-  
3 lected fields from the message buffer to the top-level and next-level associative memo-  
4 ries.

1 ~~12~~ 11. The hierarchical memory structure of claim 1 further comprising:



1 7/ 16. The hierarchical memory structure of claim 4 further comprising a plurality of  
2 records organized into common fields, wherein

3 at least one field of each record, which originally contained a corresponding  
4 value, is replaced with a unique coordinate value (UCV) that has been generated for the  
5 corresponding value, and

6 each UCV is shorter than the corresponding value that it replaces.

1 17. The hierarchical memory structure of claim 1 further comprising a plurality of  
2 records organized into common fields, wherein

3 at least one field of each record, which originally contained a corresponding  
4 value, is replaced with a unique coordinate value (UCV) that has been generated for the  
5 corresponding value, and

6 each UCV is shorter than the corresponding value that it replaces.

1 18. A method for loading a hierarchical, associative memory structure with a plu-  
2 rality of records, each record organized into common fields having values and/or don't  
3 cares, so that a data string, also having a plurality of fields, may be compared with the  
4 contents of the memory structure in order to identify a matching record, the method com-  
5 prising the steps of:

6 identifying the coordinate sub-fields of at least one selected field of the records,  
7 the selected field having distinct values or don't cares;

8 determining the number of distinct values that each coordinate sub-field has;

9 for each coordinate sub-field, computing the minimum number of bits needed to  
10 individually represent each of the distinct values and don't care, if present, for the re-  
11 spective coordinate sub-field;

12 assigning a unique coordinate value (UCV), that falls within the previously com-  
13 puted minimum number of bits, for each distinct value and don't care, if present;

14 for each record, generating a unique coordinate value sequence (UCVS) by con-  
15 catenating the UCVs assigned to the distinct values and don't care, if present, of the re-  
16 spective record; and

17 loading the hierarchical, associative memory structure with the generated UCVs.

1 19. The method of claim 18 wherein a coordinate sub-field is defined as having  
2 either all distinct values or all don't cares for all records.

1 20. The method of claim 19 wherein the records are access control entries (ACEs)  
2 of at least one access control list (ACL).

1 21. The method of claim 20 wherein the selected field corresponds to an Internet  
2 Protocol (IP) address field.

1 22. An apparatus for loading a hierarchical, associative memory structure with a  
2 plurality of records, each record organized into common fields having values and/or don't  
3 cares, so that a data string, also having a plurality of fields, may be compared with the  
4 contents of the memory structure in order to identify a matching record, the method com-  
5 prising the steps of:

6 means for identifying the coordinate sub-fields of at least one selected field of the  
7 records, the selected field having distinct values or don't cares;

8 means for determining the number of distinct values that each coordinate sub-  
9 field has;

10 for each coordinate sub-field, means for computing the minimum number of bits  
11 needed to individually represent each of the distinct values and don't care, if present, for  
12 the respective coordinate sub-field;

13 means for assigning a unique coordinate value (UCV), that falls within the previ-  
14 ously computed minimum number of bits, for each distinct value and don't care, if pres-  
15 ent;

16 for each record, means for generating a unique coordinate value sequence  
17 (UCVS) by concatenating the UCVs assigned to the distinct values and don't care, if pre-  
18 sent, of the respective record; and

19 means for loading the hierarchical, associative memory structure with the gener-  
20 ated UCVSs.

1 23. A computer readable medium containing executable program instructions for  
2 loading a hierarchical, associative memory structure with a plurality of records, each rec-  
3 ord organized into common fields having values and/or don't cares, so that a data string,  
4 also having a plurality of fields, may be compared with the contents of the memory  
5 structure in order to identify a matching record, the executable program instructions  
6 comprising steps for:

7 identifying the coordinate sub-fields of at least one selected field of the records,  
8 the selected field having distinct values or don't cares;

9 determining the number of distinct values that each coordinate sub-field has;

10 for each coordinate sub-field, computing the minimum number of bits needed to  
11 individually represent each of the distinct values and don't care, if present, for the re-  
12 spective coordinate sub-field;

13 assigning a unique coordinate value (UCV), that falls within the previously com-  
14 puted minimum number of bits, for each distinct value and don't care, if present;

15 for each record, generating a unique coordinate value sequence (UCVS) by con-  
16 catenating the UCVs assigned to the distinct values and don't care, if present, of the re-  
17 spective record; and

18 loading the hierarchical, associative memory structure with the generated UCVSs.

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